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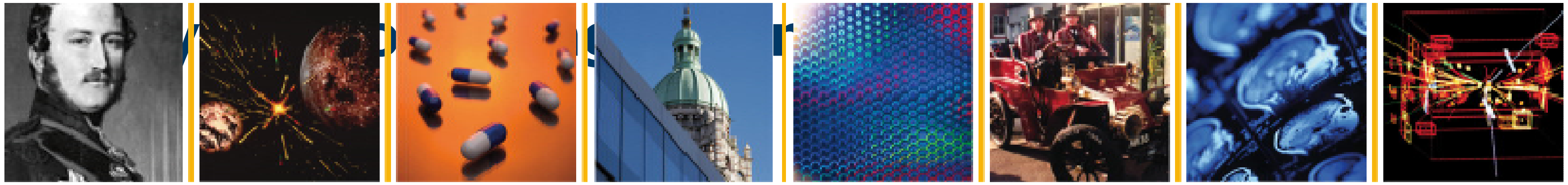
Design of Carbon Dioxide Storage



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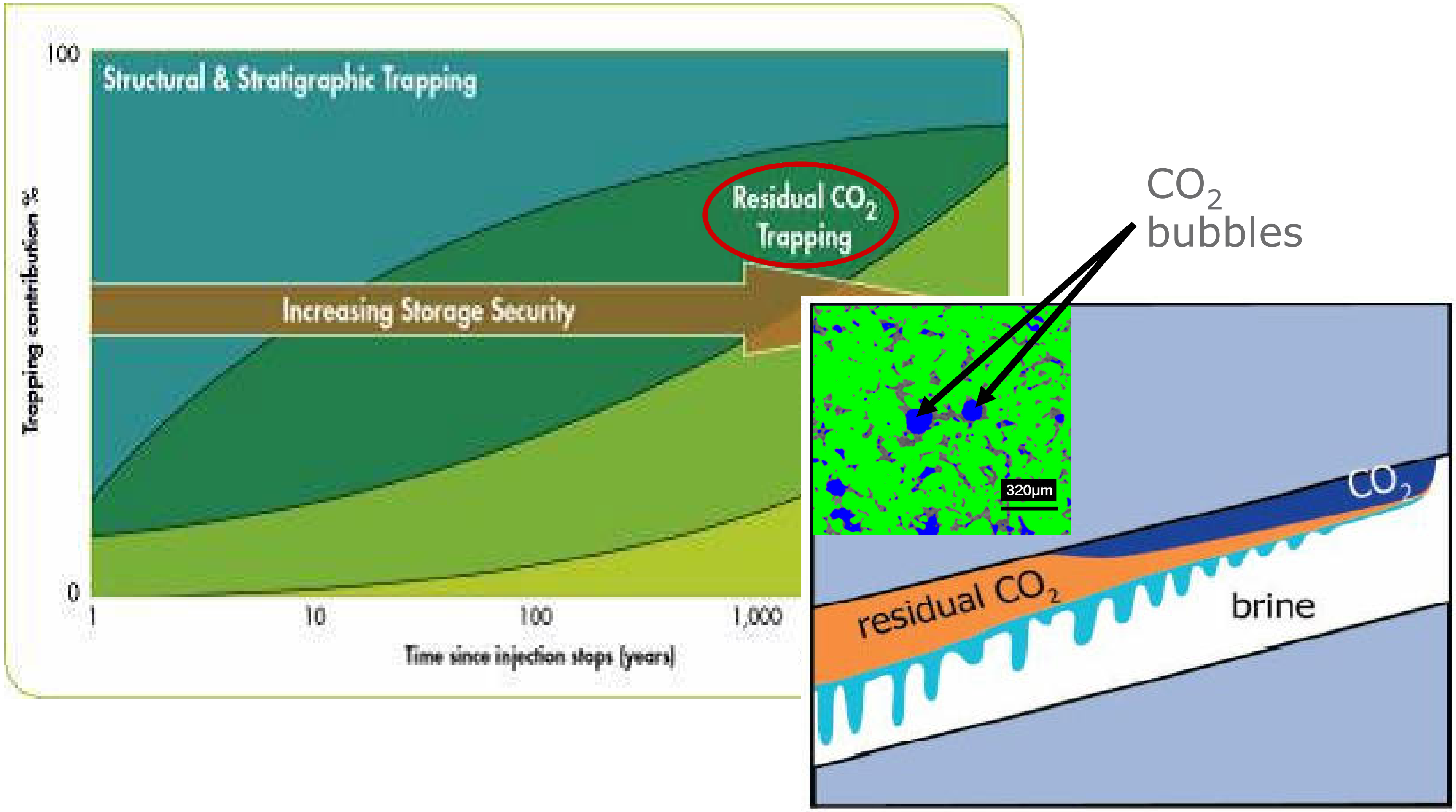
Background

In the long term, how can you be sure that the CO_2 stays underground?



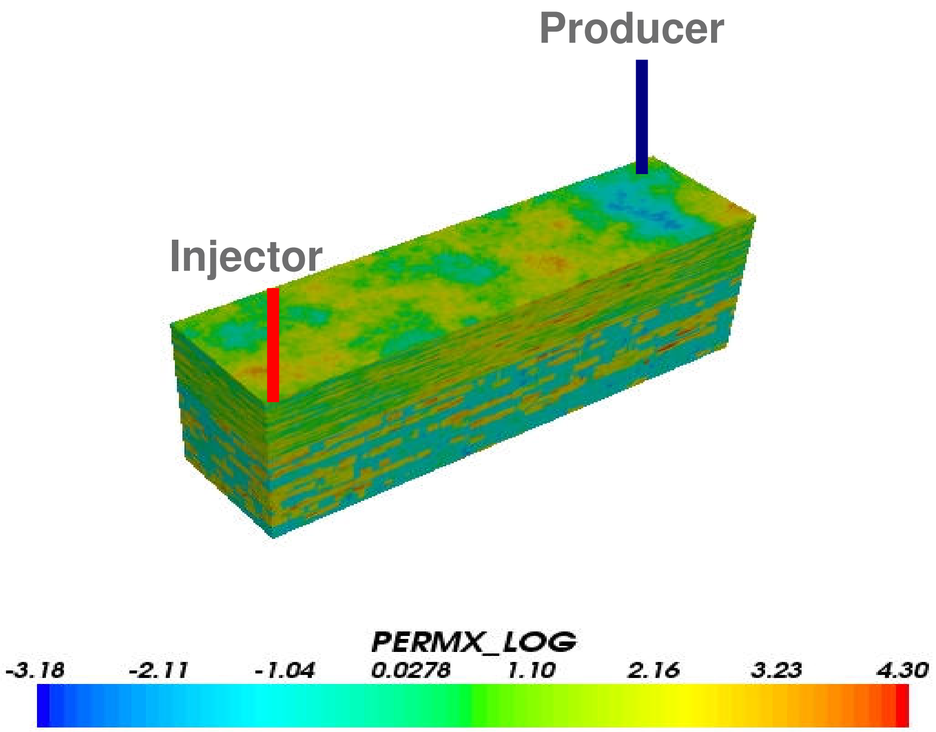
Design of CO_2 storage

A case study on a highly heterogeneous field:

❖ Use chase water to trap CO_2 during injection

❖ 1D results are used to design a stable displacement

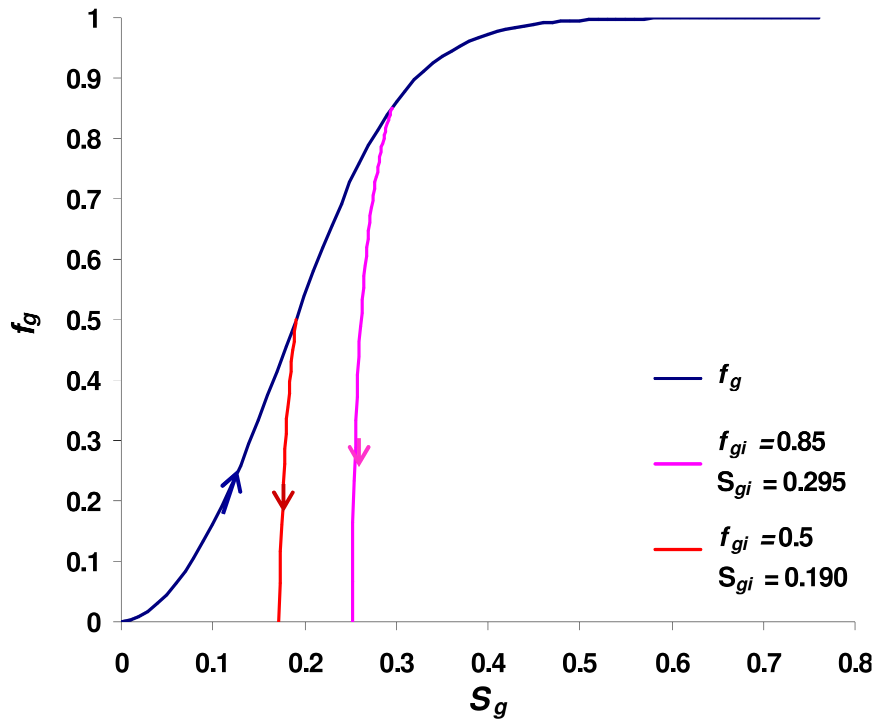
❖ Simulations are used to optimize trapping



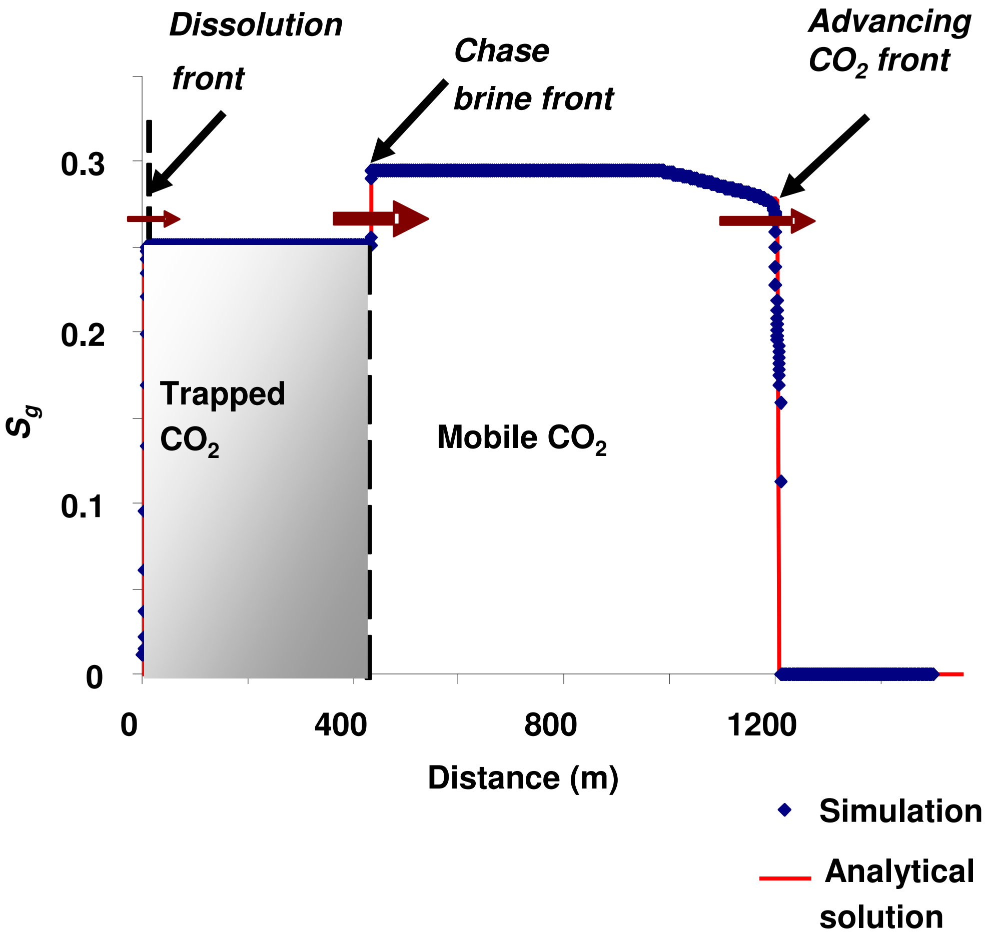
SPE 10 reservoir model, 1,200,000 grid cells (60X220X85), 7.8 Mt CO_2 injected.

Qi et al., JGGC

1D results for aquifer storage



The CO_2-phase fractional flow f_g as a function of CO_2 (gas) saturation, S_g.



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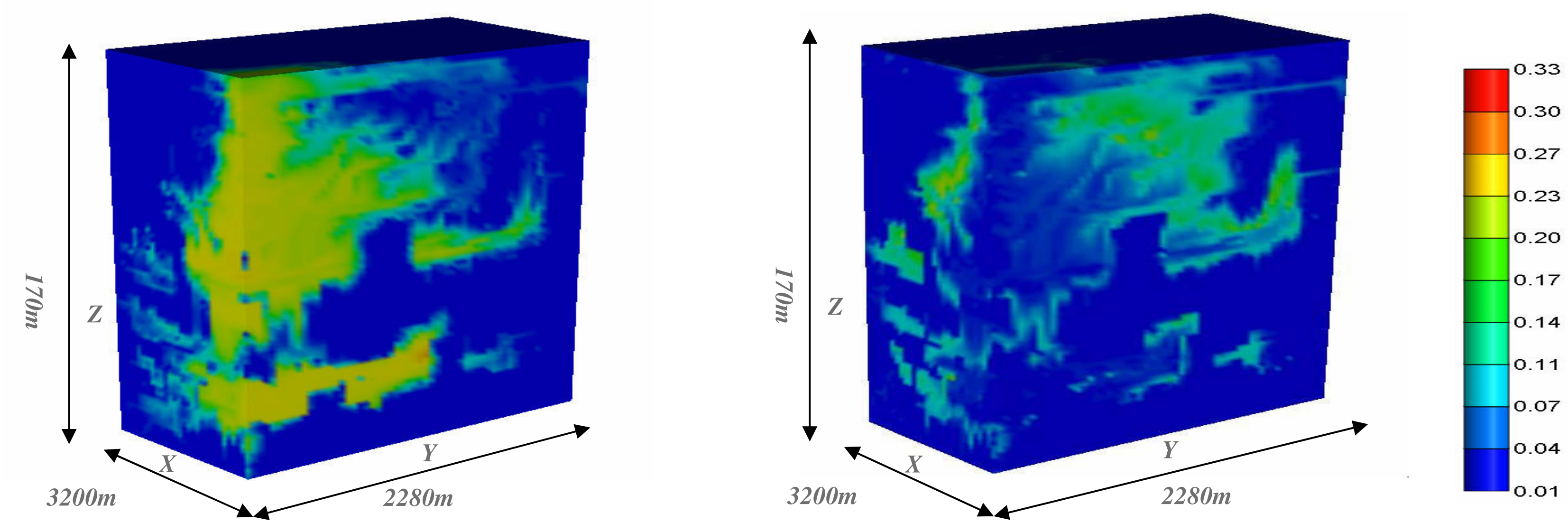
3D results for aquifer storage

20 years of water and CO_2 injection followed by 2 years of water injection in realistic geology

95% of CO_2 trapped after 4 years of water injection



Trapped CO_2 saturation

Mobile CO_2 saturation

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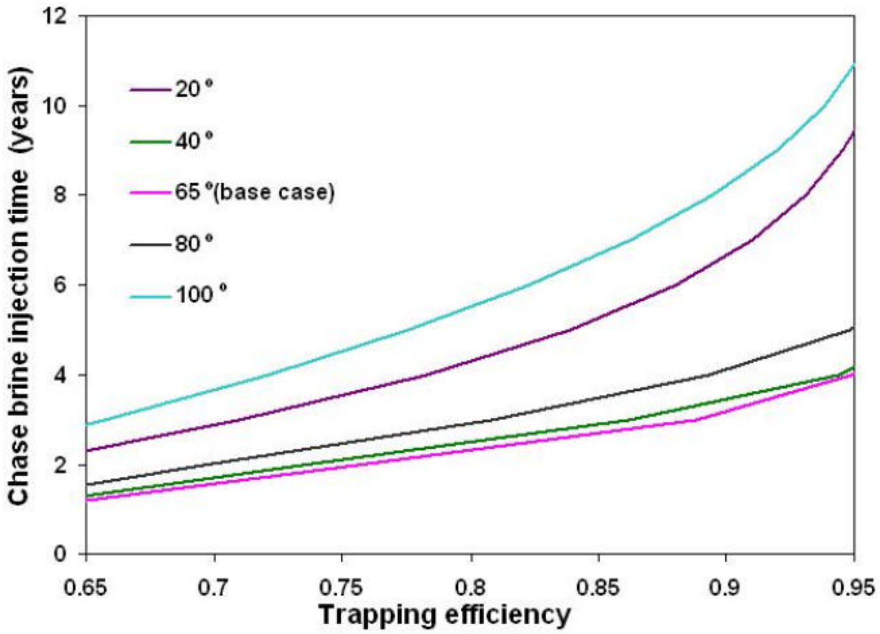
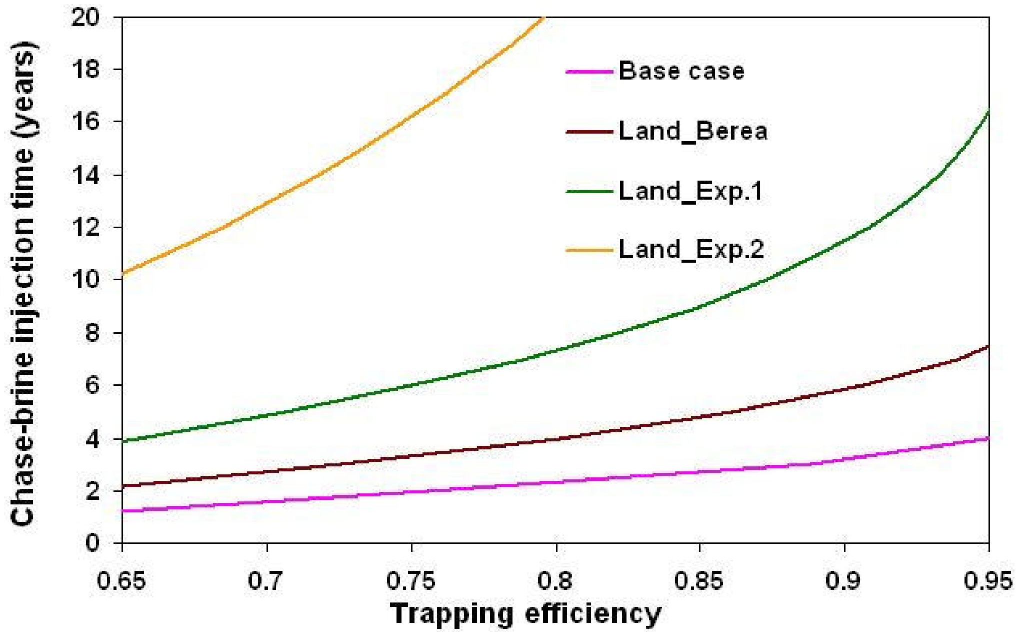
How long until the CO_2 is immobilized?

❖ Depends on wettability of rock and trapping model



	Ref.	S_{gt_max}
Land_Berea	Oak (1990)	0.37
Land_Exp.1	Suekane et al.(2008)	0.275
Land_Exp.2	Iglauer et al.	0.13



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General injection strategy

To maximize CO_2 storage in an aquifer:

❖ Inject CO_2+brine where mobility ratio = 1.0 for a stable displacement

❖ Inject chase brine that is 25% of the CO_2 mass

- ❖90-95% of the CO_2 is trapped for most realistic case
- ❖ As little as 65% may be trapped for worst case
- ❖It all rests on how much is trapped as a function of initial saturation.

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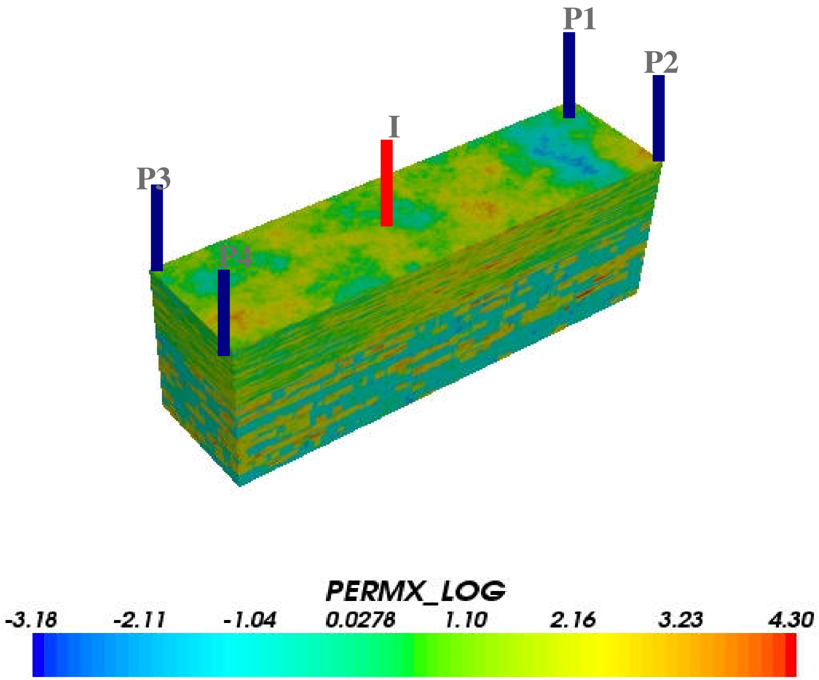
Design of carbon dioxide storage in oil fields



SPE 10 reservoir model, 1,200,000 grid cells (60X220X85). Permeability distribution and well placement

Injection Scheme:

- **Water flood the reservoir until 70% water cut ;**
- **Inject supercritical CO_2 and brine simultaneously (SWAG) at different f_{ci}, until 20% of injected CO_2 produced;**
- **Inject chase brine until trapping efficiency stops increasing.**

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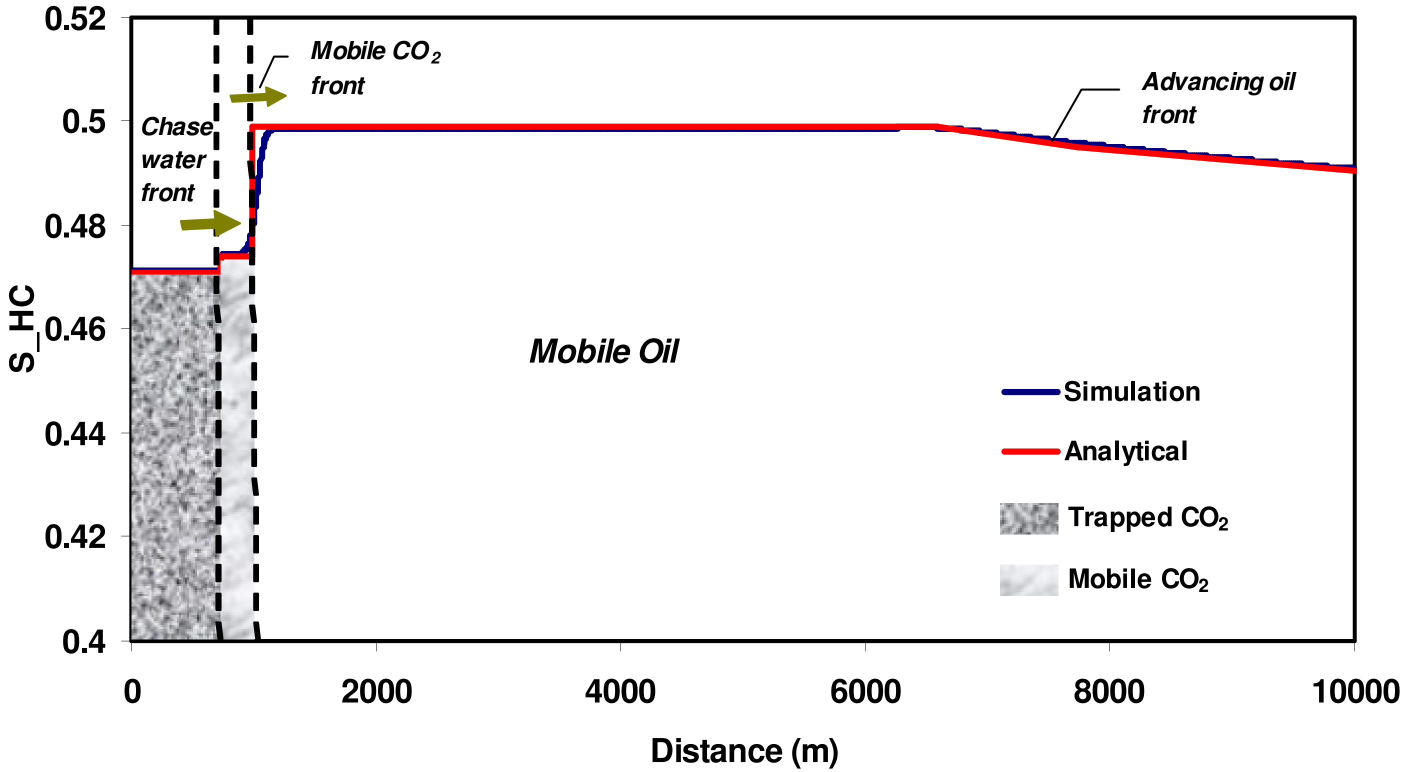
1D results for reservoir storage



- First-contact miscible CO_2 injection
- CO_2 injection at f_{CO2}=0.7 followed by chase water injection

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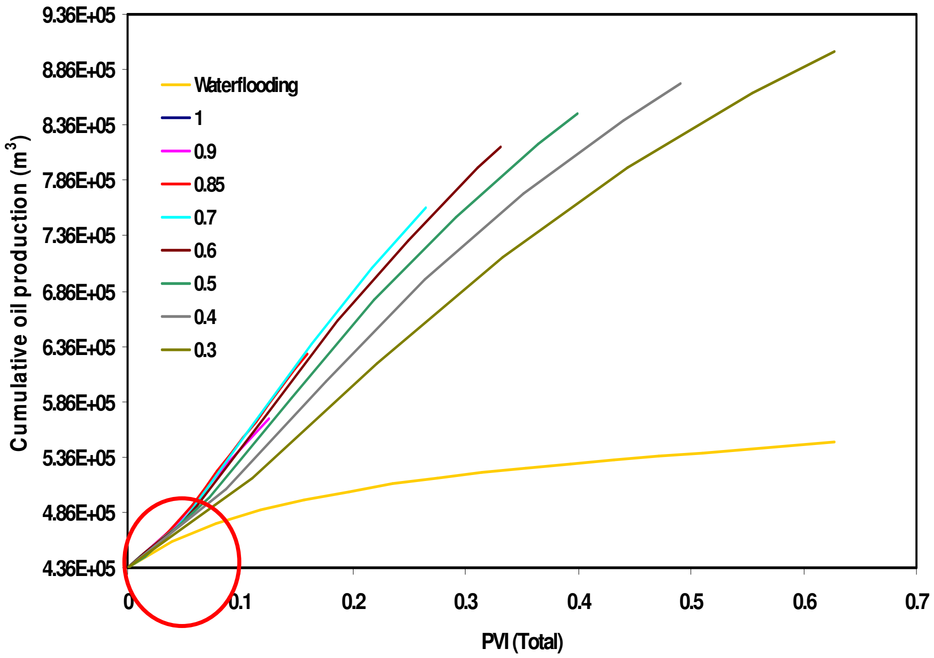
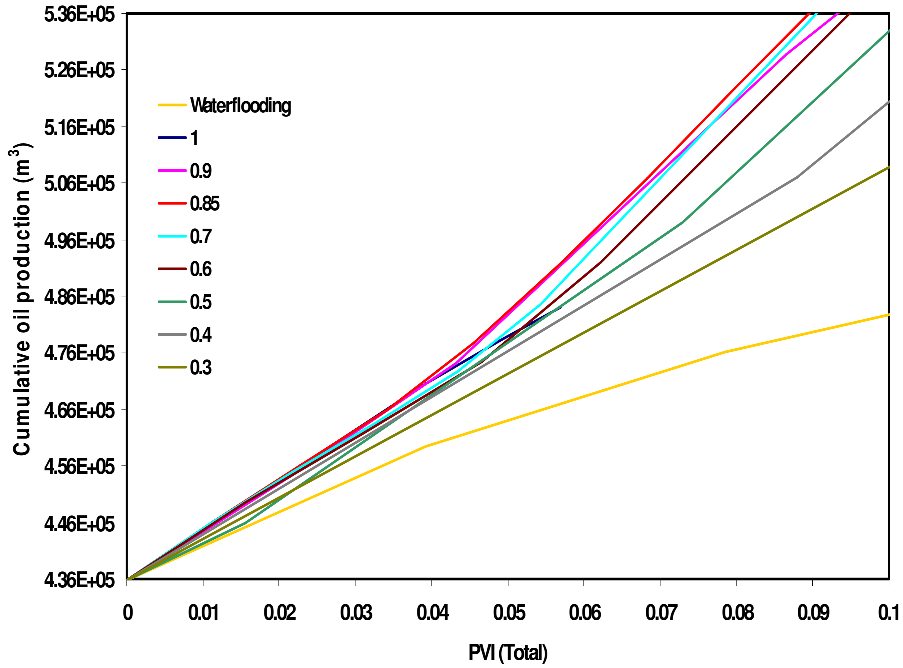
Design of carbon dioxide storage in oil fields

At the end of CO_2 injection: cumulative oil production VS. PVI





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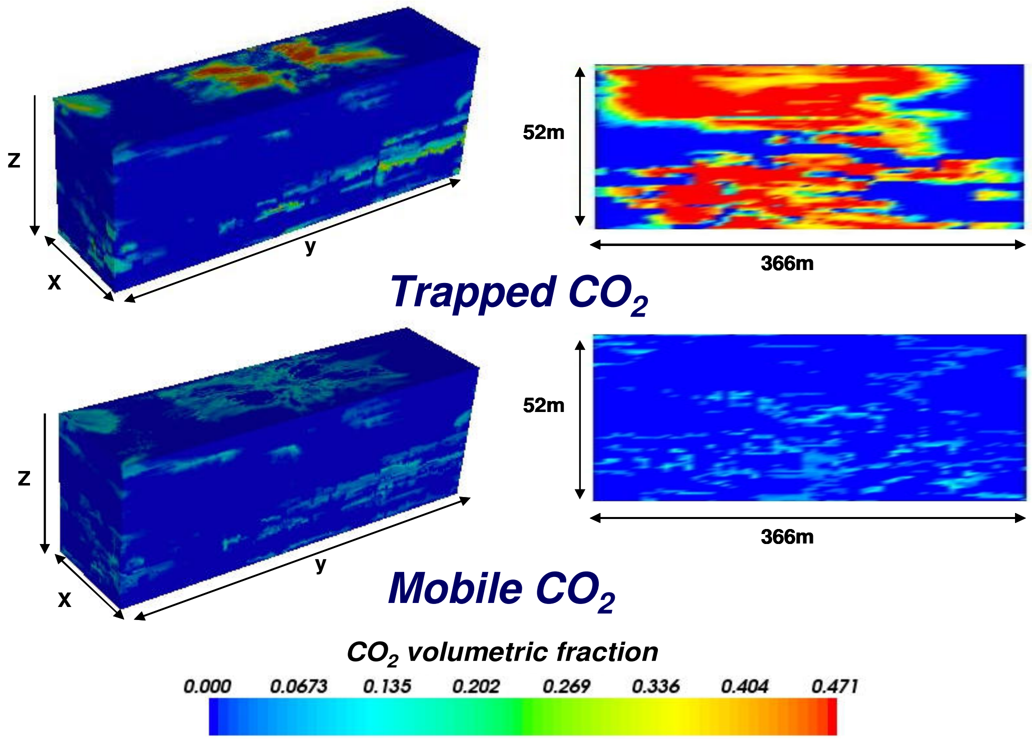
Design of carbon dioxide storage in oil fields

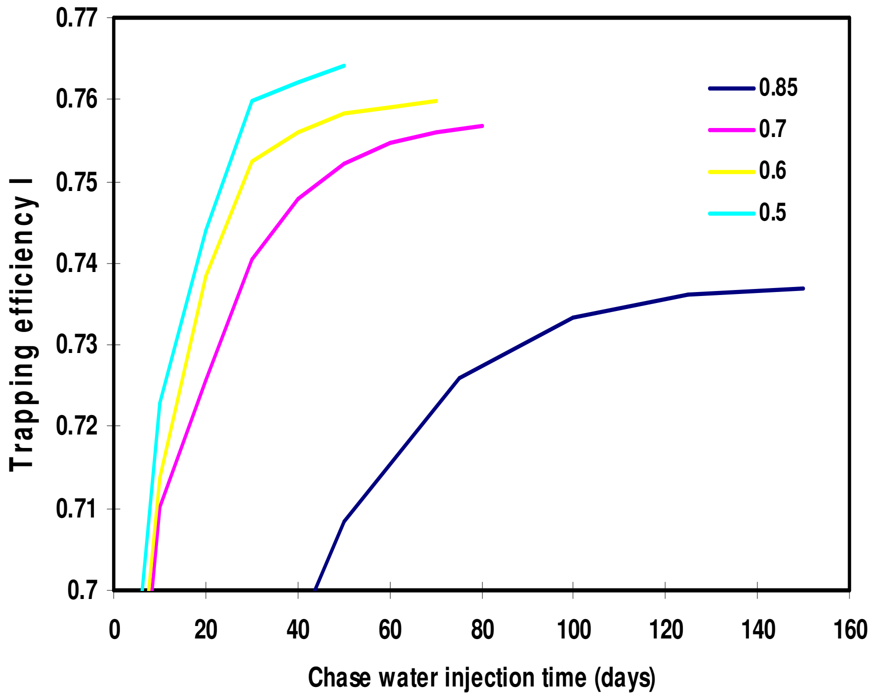


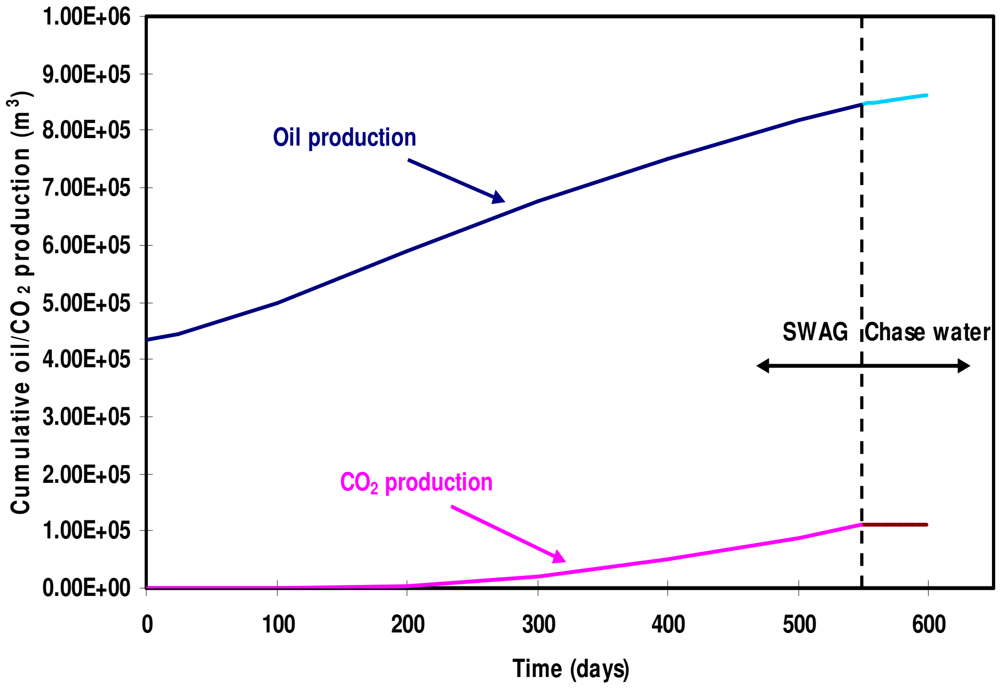
- CO_2 volumetric fraction for injected f_{ci}=0.5.
- 548 days of SWAG injection followed by 30 days of chase brine injection.
- Another 20 days brine injection (50 days in total), 76.5% of injected CO_2 trapped, or 96.5% of the total mass of CO2 stored

Qi et al., SPE 115663

Design of carbon dioxide storage in oil fields

Chase brine injection:





f_{ci}=0.5

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Conclusions

❖ Trapping is an important mechanism to store CO_2 as an immobile phase. Our study showed that brine + CO_2 injection into an aquifer can trap more than 90% of the CO_2 injected;

❖ We have proposed a design strategy for CO_2 storage in aquifers, in which CO_2 and formation brine are injected simultaneously followed by chase brine.

❖ Results are very sensitive to trapping model

❖ Streamline simulation combined with pore-scale network modelling can capture both the large-scale heterogeneity of the reservoir and the pore-scale effects of trapping.